

WHAT IS CLAIMED AS NEW AND DESIRED TO BE SECURED BY LETTERS
PATENT OF THE UNITED STATES IS:

1. A mass spectrometer, comprising:
 - an ion source configured to produce ions from a sample;
 - an extraction device configured to extract ions from the ion source;
 - a time-of-flight (TOF) mass analyzer configured to analyze at least one of a first extraction of ions and ion fragments of said first extraction;
 - an ion trap (IT) mass analyzer configured to analyze at least one of a second extraction of the ions and ion fragments of said second extraction; and
 - an ion guiding optical element configured to guide at least one of the first extraction and said ion fragments of said first extraction into the TOF mass analyzer in a normal mode of operation and to guide at least one of the second extraction and said ion fragments of said second extraction into the IT mass analyzer in a tandem mode of operation.
2. The spectrometer as in Claim 1, wherein the ion source comprises:
 - an array of samples.
3. The spectrometer as in Claim 1, wherein the ion source comprises:
 - a vacuum matrix-assisted laser desorption/ionization (MALDI) source.
4. The spectrometer as in Claim 1, wherein the ion source is configured to produce ions at normal atmospheric pressure.
5. The spectrometer as in Claim 4, wherein the ion source comprises:
 - an electrospray ionization source.
6. The spectrometer as in Claim 4, wherein the ion source comprises:
 - an atmospheric pressure MALDI source.
7. The spectrometer as in Claim 1, wherein the extracting device is configured to

time-lag focus extracted ions.

8. The spectrometer as in Claim 1, wherein the TOF mass analyzer comprises:
a TOF ion detector configured to detect the first extraction and said ion fragments of said first extraction, and
time-of-flight optics configured to direct the first extraction and said ion fragments of the first extraction to the TOF ion detector and to mass-separate the first extraction and said ion fragments of the first extraction according to a mass-to-charge ratio.

9. The spectrometer as in Claim 8, wherein the time-of-flight optics comprises:
an acceleration grid configured to accelerate the first extraction and said ion fragments of said first extraction orthogonally to an axis of the extraction device; and
a reflectron configured to reflect accelerated ions towards the TOF ion detector.

10. The spectrometer as in Claim 8, wherein the time-of-flight optics comprises:
a reflectron.

11. The spectrometer as in Claim 10, wherein the reflectron is an end-cap reflectron comprising:
a cap of the reflectron; and
a reflecting end electrode electrically isolated from the cap and configured to reflect the first extraction and said ion fragments of said first extraction to the TOF ion detector.

12. The spectrometer as in Claim 11, wherein the cap is configured with a through-hole to permit said second extraction and said ion fragments of said second extraction to transit through the TOF mass analyzer and enter the IT mass analyzer.

13. The spectrometer as in Claim 1, wherein the TOF mass analyzer comprises:
a linear TOF mass analyzer.

14. The spectrometer as in Claim 13, wherein the linear TOF mass analyzer is

configured to transit said first extraction and said ion fragments of said first extraction through said TOF mass analyzer and through said IT mass analyzer and detect transited ions by an IT ion detector.

15. The spectrometer as in Claim 1, wherein the IT mass analyzer comprises:
an IT ion detector configured to detect said second extraction and said ion fragments of said second extraction, and
trapping optics configured to trap a portion of said second extraction in a trapping electric field, to isolate and fragment trapped ions, to mass separate the trapped ions according to a mass-to-charge ratio, and to direct trapped ions of a predetermined mass-to-charge ratio to the IT ion detector.

16. The spectrometer as in Claim 15, wherein the IT mass analyzer comprises:
a quadrupole ion trap mass analyzer, including,
a ring electrode,
an entrance ion trap end cap, and
an exit ion trap end cap,
whereby voltages on the ring electrode, the entrance and exit end caps confine ions in the ion trap and activate or eject confined ions in the ion trap to the ion trap detector.

17. The spectrometer as in Claim 1, wherein the TOF ion analyzer and the IT ion analyzer utilize a single ion detector.

18. The spectrometer as in Claim 1, wherein the ion guiding optical element is configured to establish a first electric field configuration to guide said first extraction and said ion fragments of said first extraction in the TOF mass analyzer in the normal mode of operation and to establish a second electric field configuration to guide said second extraction and said ion fragments of said second extraction to the IT mass analyzer in the tandem mode of operation.

19. The spectrometer as in Claim 1, wherein the ion guiding optical element

comprises:

at least one optical element of the extraction device, the TOF mass analyzer, and the IT mass analyzer.

20. The spectrometer as in Claim 1, wherein the ion guiding optical element comprises at least one multipole ion guide.

21. The spectrometer as in Claim 1, further comprising:

a computer configured to control operational voltages on at least one of the ion source, the extraction device, the TOF mass analyzer, and the ion guiding optical element.

22. A method of operating a mass spectrometer, comprising the steps of:
producing ions from a sample containing a plurality of atoms or molecules;
extracting the ions from an ion source;
selecting between a time-of-flight mass analyzer and an ion trap mass analyzer;
directing at least one of extracted ions and ion fragments of the extracted ions to said selected mass analyzer based on said selecting step;

mass-separating directed ions and fragments of the directed ions according to a mass-to-charge ratio;

detecting mass-separated ions with said selected analyzer; and

producing at least one of a normal mass spectrum and a tandem mass spectrum.

23. The method as in Claim 22, wherein the step of producing ions comprises:
producing ions from an array of samples to increase sample analysis throughput.

24. The method as in Claim 22, wherein the step of producing ions comprises:
producing the ions from a vacuum matrix-assisted laser desorption/ionization MALDI source.

25. The method as in Claim 22, wherein the step of producing ions from a vacuum MALDI source comprises:

providing a laser pulse on the sample to desorb and ionize a portion of the plurality of atoms or molecules from the sample.

26. The method as in Claim 22, wherein the step of producing ions comprises:
producing ions at normal atmospheric pressure.

27. The method as in Claim 26, wherein the step of producing ions at normal atmospheric pressure comprises:
producing ions from an electrospray ionization source.

28. The method as in Claim 26, wherein the step of producing ions from an ion source at normal atmospheric pressure comprises:
producing ions from an atmospheric pressure MALDI source.

29. The method as in Claim 28, wherein the step of producing ions from an atmospheric pressure MALDI source comprises:
providing a laser pulse on the sample to desorb and ionize a portion of the plurality of atoms or molecules from the sample.

30. The method as in Claim 22, wherein the step of extracting the ions comprises:
applying a positive voltage to a sample stage to extract positive ions.

31. The method as in Claim 22, wherein the step of extracting the ions comprises:
applying a negative voltage to a sample stage to extract negative ions.

32. The method as in Claim 22, wherein the step of extracting the ions comprises:
extracting the ions utilizing a time-lag focusing technique.

33. The method as in Claim 32, wherein the step of extracting the ions utilizing a time-lag focusing technique comprises:
applying an extraction voltage pulse on a sample stage after a laser pulse desorbs and

ionizes a portion of said plurality of atoms or molecules to produce said ions.

34. The method as in Claim 22, wherein the step of selecting comprises:
applying a first controllable voltage to an ion guiding optical element to direct extracted ions to the time-of-flight mass analyzer.

35. The method as in Claim 22, wherein the step of directing comprises:
guiding at least one of the extracted ions and said ion fragments of the extracted ions with at least one optical element of the TOF mass analyzer and the IT mass analyzer.

36. The method as in Claim 22, wherein the step of directing comprises:
guiding at least one of the extracted ions and said ion fragments of the extracted ions with multipole ion guides.

37. The method as in Claim 22, wherein the step of directing comprises:
directing at least one of the extracted ions and said ion fragments of the extracted ions by orthogonally accelerating the extracted ions.

38. The method as in Claim 37, wherein the step of directing by orthogonally accelerating the extracted ions comprises:
accelerating at least one of the extracted ions and said ion fragments of the extracted ions orthogonal to an axis of an extraction device.

39. The method as in Claim 37, wherein the step of accelerating orthogonal to an axis of the extraction device comprises:
applying periodically potentials between acceleration grids located on an axis with the extraction device.

40. The method as in Claim 22, wherein the step of mass-separating comprises:
mass-separating the directed ions and said ion fragments of the directed ions with a linear TOF mass analyzer.

41. The method as in Claim 40, wherein the step of mass-separating with a linear TOF mass analyzer comprises:

guiding at least one of the extracted ions and said ion fragments of the extracted ions through said TOF mass analyzer and through said IT mass analyzer; and
detecting guided ions and fragments of the guided ions by an IT ion detector.

42. The method as in Claim 22, wherein the step of mass-separating comprises:
mass-separating the directed ions and said ion fragments of the directed ions with a reflectron TOF mass analyzer.

43. The method as in Claim 42, the step of mass-separating with a reflectron TOF mass analyzer comprises:

applying a reflecting potential to a reflecting electrode of the reflectron TOF mass analyzer;
reflecting at least one of the extracted ions and said fragments of the extracted ions;
and
detecting reflected ions and ion fragments of said reflected ions with a TOF ion detector.

44. The method as in Claim 22, wherein the step of selecting comprises:

applying a second controllable voltage to an ion guiding optical element to direct the at least one of the extracted ions and said ion fragments of the extracted ions to the ion trap analyzer.

45. The method as in Claim 22, wherein the step of mass-separating comprises:

trapping said at least one of the extracted ions and said fragments of the extracted ions in an ion trap; and
mass-isolating and mass-fragmenting trapped ions.

46. The method as in Claim 45, wherein the step of trapping with an ion trap

comprises:

scanning a trapping field between an entrance ion trap end cap, an exit ion trap end cap, and a ring electrode of a quadrupole ion trap mass analyzer.

47. The method as in Claim 45, wherein the step of trapping with an ion trap comprises:

scanning in frequency a radio frequency signal on a ring electrode of a quadrupole ion trap mass analyzer.

48. The method as in Claim 45, wherein the step of trapping with an ion trap comprises:

scanning in voltage a radio frequency signal on a ring electrode of a quadrupole ion trap mass analyzer.

49. The method as in Claim 22, wherein the step of detecting mass-separated ions comprise:

utilizing a single ion detector as both an TOF ion detector and an IT ion detector.

50. A mass spectrometer, comprising:

means for producing ions from an ion source including a sample containing a plurality of atoms or molecules;

means for extracting the ions from the ion source;

means for selecting between a time-of-flight mass analyzer and an ion trap mass analyzer;

means for directing at least one of extracted ions and ion fragments of the extracted ions;

means for mass separating directed ions and fragments of the directed ions according to a mass-to-charge ratio;

means for detecting mass-separated ions with said selected analyzer; and

means for producing both a normal mass spectrum and a tandem mass spectrum.

51. The spectrometer as in Claim 50, wherein the means for producing ions comprises:

means for producing ions from an array of samples to increase sample analysis throughput.

52. The spectrometer as in Claim 50, wherein the means for producing ions comprises:

means for producing the ions from a vacuum matrix-assisted laser desorption/ionization (MALDI) source.

53. The spectrometer as in Claim 50, wherein the means for producing ions from a vacuum MALDI source comprises:

means for desorbing and ionizing a portion of the plurality of atoms or molecules from the sample.

54. The spectrometer as in Claim 50, wherein the means for producing ions comprises:

means for producing the ions at normal atmospheric pressure.

55. The spectrometer as in Claim 50, wherein the means for extracting the ions comprises:

means for extracting the ions utilizing a time-lag focusing technique.

56. The spectrometer as in Claim 50, wherein the means for selecting comprises:

means for guiding at least one of the extracted ions and said ion fragments of the extracted ions to at least one of the time-of-flight mass analyzer and the ion-trap mass analyzer.

57. The method as in Claim 50, wherein the means for directing comprises:

means for guiding at least one of the extracted ions and said ion fragments of the extracted ions with an optical element from at least one of the TOF mass analyzer and the IT

mass analyzer.

58. The spectrometer as in Claim 50, wherein the means for directing comprises:
means for guiding at least one of the extracted ions and said ion fragments of the
extracted ions with a multipole ion guide.

59. The spectrometer as in Claim 50, wherein the means for directing comprises:
means for accelerating orthogonal to an axis of the means for extracting at least one of
the extracted ions and said ion fragments of the extracted ions to the TOF mass analyzer.

60. The spectrometer as in Claim 50, wherein the means for mass-separating
comprises:
means for reflecting at least one of the extracted ions and said ion fragments of the
extracted ions to the means for detecting.

61. The spectrometer as in Claim 50, wherein the means for mass-separating
comprises:
means for scanning a voltage on said means for mass-separating.

62. The spectrometer as in Claim 50, wherein the means for mass-separating
comprises:
means for scanning in frequency a radio frequency signal on said means for mass-
separating.

63. The spectrometer as in Claim 50, wherein the means for mass-separating
comprises:
means for scanning in voltage a radio frequency signal on said means for mass-
separating.

64. A computer program product, comprising:
a computer storage medium and a computer program code mechanism embedded in

the computer storage medium for causing a computer to control a mass spectrometer, the computer program code mechanism comprising:

- a first computer code device configured to control an extraction voltage applied to an extraction device to extract ions from an ion source; and

- a second computer code device configured to control a guiding voltage on an ion guiding optical element to guide a first extraction and ion fragments of said first extraction from an ion source to a time-of-flight TOF mass analyzer in a normal mode of operation and to guide a second extraction and ion fragments of said second extraction to an ion trap IT mass analyzer in a tandem mode of operation.

65. The computer program product as in Claim 64, wherein the second computer code device is configured to control said guiding voltage to a first control voltage to direct the first extraction and said ion fragments of the first extraction to the TOF mass analyzer and to a second control voltage to direct the second extraction and said ion fragments of the second extraction to the IT mass analyzer.

66. The computer program product as in Claim 64, wherein the second computer code device is configured to control said guiding voltage on an acceleration grid to accelerate the first extraction and said ion fragments of the first extraction orthogonally to an axis of the extraction device, and further comprising:

- a third computer code device configured to control a reflection voltage on a reflectron configured to reflect accelerated ions towards TOF ion detector in the TOF mass analyzer.

67. The computer program product as in Claim 64, wherein the second computer code device is configured to control a reflection voltage on a reflecting end electrode of the TOF ion detector to reflect the first extraction and said ion fragments of the first extraction to a TOF ion detector in the TOF mass analyzer.

68. The computer program product as in Claim 64, further comprising:

- an third computer code device configured to control an RF voltage on a ring electrode of a quadrupole IT mass analyzer;

a fourth computer code device configured to control an entrance voltage on an entrance ion trap end cap of the quadrupole IT mass analyzer; and

a fifth computer code device configured to control an exit voltage on an exit ion trap end cap of the quadrupole IT mass analyzer,

wherein the third, fourth, and fifth computer control devices are configured to control said RF, entrance, and exit voltages, respectively, so as confine the second extraction and said ion fragments of the second extraction in the IT mass analyzer and subsequently eject confined ions to an ion trap detector of said IT mass analyzer.

69. The computer program product as in Claim 64, further comprising:

a third computer code device configured to control a detection voltage on an IT ion detector of the IT mass analyzer; and

a fourth computer control device configured to calculate an ion flux based on a current in said IT ion detector.

70. The computer program product as in Claim 64, further comprising:

a third computer code device configured to control a detection voltage on a TOF ion detector of the TOF mass analyzer; and

a fourth computer control device configured to calculate an ion flux based on a current in said TOF ion detector.

71. The computer program product as in Claim 64, further comprising:

a third computer code device configured to control a laser voltage controlling pulse firing of a laser, said laser pulse generating ions from said ion source.